To Assess the Performance of Solar Home System Installed by the Residents of Coimbatore City and Design a Residential Solar-Powered Device Based on their Preference

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INTRODUCTION

Consumers prefer to use traditional sources of energy for their daily needs, such as coal, oil, etc., which are limited in quantity and will deplete soon in the coming days. With an increase in population, there is a demand for more energy. Relying on fossil fuels to meet energy demands has a diverse effect on our environment. The consequences of using fossil fuels can be the emission of various sulfur and nitrous oxides. The emission of chemicals results in climate changes where winters are shorter and summers are longer and hotter. As a result, climate changes are a significant reason to opt for renewable sources such as solar energy. Hence, it requires research in the field, which will result in consumer behavior change.

Scientists and researchers are striving to find out simple methods of harnessing solar energy at the household level. Though few consumers are aware of solar home systems, they are still hesitant to opt them due to the risk involved, unfamiliarity with the technology, and high installation cost. As the knowledge is not being extended to the people in need, people are not much aware of the techniques and devices available in the market. Besides, all the exhibition and marketing agencies highlight only one product they deal with. It is obligatory for the consumers that they should be aware of environmental changes caused by our lifestyle and how solar energy can be helpful to combat these changes. The study will help people know the benefits of solar energy as an alternative energy source to meet the energy demands of their daily activities.

A survey was conducted among the households using at least one solar device. Despite household surveys, a market survey was also conducted to know the viewpoint of manufacturers and dealers. A solar-powered device was developed during the research period and demonstrated among the target audience. Babu et al. (2021) suggested to use solar-powered irons to harness the energy in the sun. This innovation promises to improve the poverty associated with the ironing industry as well as the environmental issues it causes. India receives enough sunlight to produce solar power 3,000 times more than its total current energy consumption. The investigator designed the model with functionality and cost-efficiency in mind. Individuals could use the iron box effectively after only 15 minutes of tutorials. The solar-powered batteries charged in under five hours and lasted for six hours. Overall, the goal of the solar-powered iron was also to improve the economic and health outcomes of the street vendors working in the ironing industries. In the long run, with further innovation, they intended to develop a cart

prototype with solar panels and batteries that could last up to eight years. This ambitious plan favors sustainability for two parties: vendors and the environment. With the use of Solar-powered devices by the people, India shows promise for improved environmental conditions and reduced poverty rates. Although expensive, new technologies are constantly emerging. Given the fact that street vending is a widespread market in India, a solar powered iron has the potential to transform the harmful coal-sourced iron industry into one that is profitable and environmentally conscious. An awareness program was also organized for the interested respondents to disseminate knowledge on how they can save electricity and protect the environment using solar home systems that are available in the market.

Delineation of the problem

1.What are the strategies employed by households to address the challenges they face while utilizing solar home systems.

2. Do households possess knowledge regarding the complete range of solar home systems that are currently available in the market?

3. Which promotional initiatives do manufacturers and dealers implement?

4. Are the residents of Coimbatore conscious of governmental endeavors aimed at promoting the adoption of solar home systems?

5. To what extent will the awareness program influence the households?

Objectives of the study

1. Determine the efficacy of solar home systems utilized by households in selected neighborhoods of Coimbatore.
2. Summarize the selected families' level of knowledge on the use and operation of other solar home systems that are available in the market.
3. Develop a solar device (iron box) that is chosen by the targeted households and evaluate its operational efficacy.
4. Educate people about the importance of utilizing solar household systems, their accessibility, and government efforts to promote their use.

Scope of the study

The solar-powered iron box developed during the research efficiently ironed the clothes by acquiring crease-free clothes. Solar-powered iron boxes not only used solar energy but also reduced the energy consumption of the households as well as Iron men. The study would possibly give a reference point for succeeding researchers to develop an alternative method to deal with energy consumption patterns.

The present study encouraged households to adopt a solar home system for day-to-day activities and enabled them to use new and renewable energy sources to protect our environment. It can be possible for households to get additional income from the sale of energy produced by solar panels installed by them.

It also provided valuable information to households using solar home systems, such as care and maintenance tips, operation of devices, government subsidies, and how to deal with the limitations by the experts.

The study would draw the attention of local authorities and policymakers of Coimbatore city in framing new policies to adopt solar devices, protect the environment, and reduce energy consumption patterns.

Constraints of the research

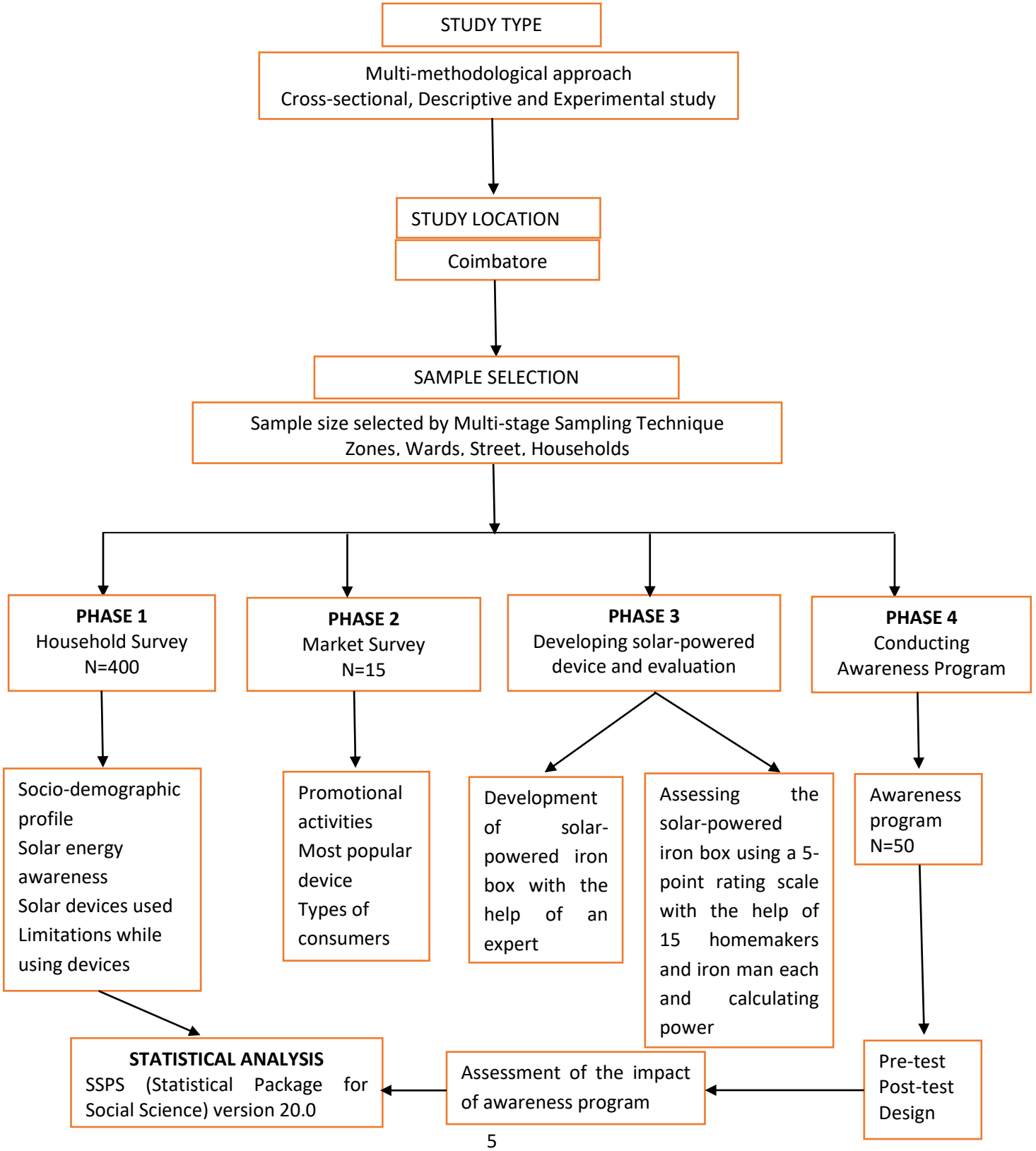
• The study's sample was restricted to a subset of the Coimbatore urban and semi urban population

• The research was specifically designed for households that possessed and utilized a minimum of one solar device.

• Consumers' perspectives, beliefs, and experiences may influence a shift in their perceptions over time.

• Because the research was carried out during the Covid-19 period, the awareness campaign was affected.

FLOW CHART OF THE METHDOLOGY FOLLOWED



Phase 1

Conducting a Household Survey

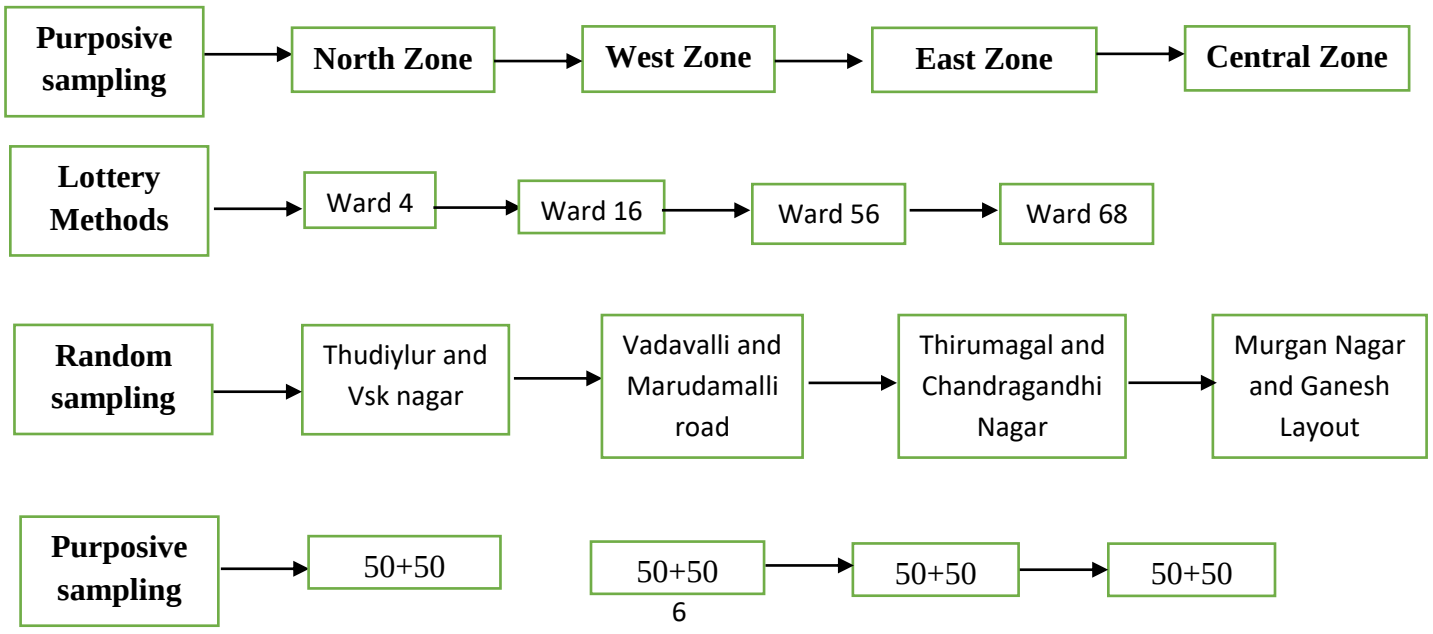
1. Identifying the area of study

Coimbatore city was the study area as the city receives abundant solar energy, availability of households using solar device as well manufactures and dealers of solar home systems, and familiarity of the investigator with the city was the rationale for choosing the area.

2. Selecting the sample

The selected samples were using at least one solar device because those who owned and operated a solar home system could share their experience regarding the operation and limitations experienced while using the solar home system. The researcher surveyed from July 2019 to January 2020. The researcher gathered data from the website of the TEDA on the households using at least one solar device. TEDA website enlisted one thousand three hundred households in Coimbatore city using solar home systems. The researcher separated the households according to their zones and wards.

3. Sampling procedure adopted



4. Research tool used

The interview was conducted by the researcher using a well-prepared interview schedule. Before conducting the main study, the interview schedule was verified by the supervisor, and validated by the subject expert as well as a statistician. The interview schedule was also pre tested among 50 samples selected randomly and necessary modifications were made accordingly.

5. Conducting the research work

The investigator took responsibility for delivering the interview schedule and collecting the data. The interview was conducted through personal contact one at a time at the convenience of the households. The researcher explained the purpose of the study to the participants, and the required information was gathered and recorded side by side. For each household, it took 30-45 minutes to finish the schedule. Finally, the researcher scrutinized the interview schedule to cross-check whether the respondent answered all the questions.

6. Data analysis

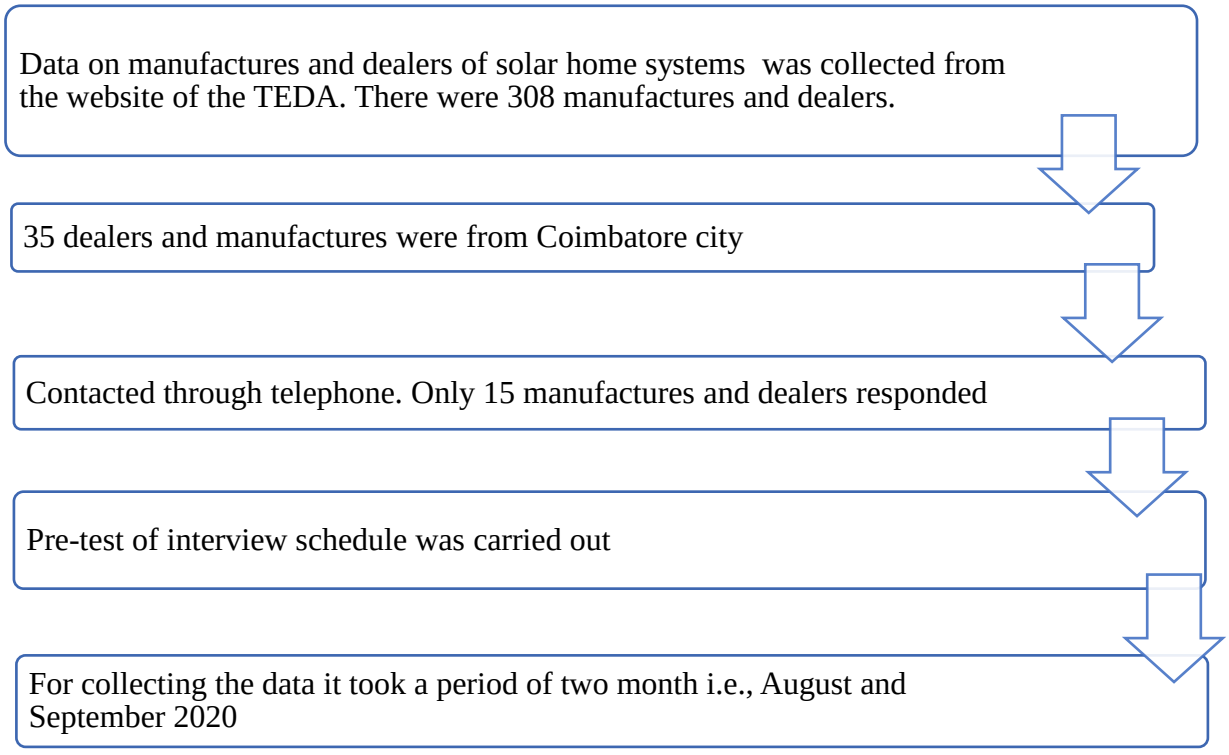
Data were analyzed using the SPSS (20.0) version. The investigator provided the questions in the interview schedule in chronological order. Data was categorized and displayed in Tables on different aspects. Results were coded for every question and then evaluated in the percentage analysis. The Chi-Square test was performed to compare the performance of the solar home systems based on the socio-demographic characteristics and building features of the households.

A t-test was carried out to compare the awareness level and perception score on the solar home systems used based on the different socio-demographic characteristics of the households.

ANOVA was applied to find out the awareness score and perception score on the solar home system based on the socio-demographic characteristic of the households.

Phase 2

Administrating a Market Survey


Data on manufactures and dealers of solar home systems was collected from the website of the TEDA. There were 308 manufactures and dealers.
35 dealers and manufactures were from Coimbatore city
Contacted through telephone. Only 15 manufactures and dealers responded
Pre-test of interview schedule was carried out
For collecting the data it took a period of two month i.e., August and September 2020

Phase 3

Evolving a Solar Powered Device and Evaluating Its Performance

During the interview schedule, the researcher gave a list of certain viable household items that they would like to operate using solar energy in future. Most of the households chose the iron box (36.0 %) because it is a device that everyone uses often at their home to iron the clothes. Hair trimmer and dresser got a response rate of 18.8 per cent, followed by kettle fifteen per cent. The mixer grinder got a response rate of 11 per cent, and the toaster got an eight per cent response.

The newly designed solar iron box is unique with the following features - handy, convenient to use at home, durable, and most importantly, it uses sunlight to work, which is renewable energy and non-polluting. The researcher developed a solar iron box with the help of an engineer who deals in designing solar home systems.

1. **Selection of material and cost of fabricating iron box**

The researcher chose materials based on the suggestions given by the expert and cost was computed.

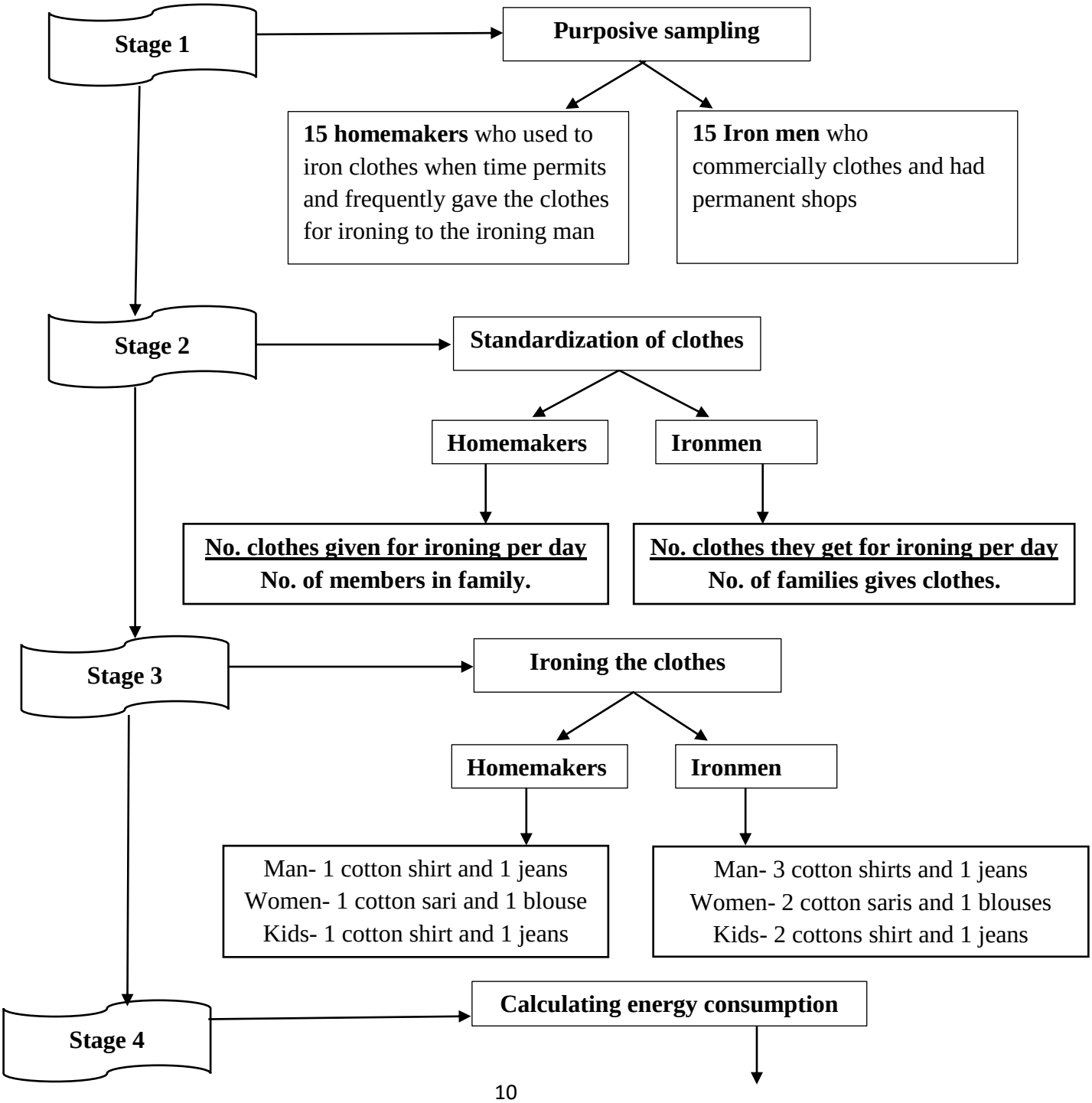
Table 3.1 Cost of fabrication of solar iron box

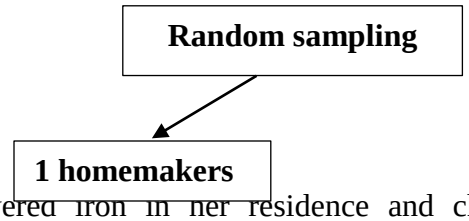
Particulars	**Amount (Rs)**
Acrylonitrile Butadiene Styrene plastic used for the handle	100
Non-stick coated, aluminium casting plate for heating	500
(4-2) Aluminum coil for heating	300
120 watts heating the coil	3000
12 V DC and 10-ampere current flow	1000
(2X2.5sqmm) cable used	200
Crocodile connector used for supply through the battery	100
5mm led (red) for indication purpose is used	50
Solar panels	5000
Battery backup	7000
Solar charger	2500
150 W coil	2000
Connecting cable	200
Total	21,950

2. **Evaluating the performance of the device on its design and operational aspects**

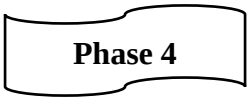
The researcher evaluated the device in terms of its design aspects such as weight, height, width, durability, cost, and appearance of the solar iron box. She also evaluated solar iron box based on operational aspects such as the extent of safety in use, ease of operation, care, and maintenance required, rapid heat, safe on all types of fabrics, efficiency in removing crease, ease of storing, space occupied and comfortable to hold. Fifteen homemakers and fifteen iron men assessed the device. The researcher developed a scorecard to evaluate the device.

FLOW OF THE METHODOLOGY FOLLOWED FOR THE EVALUATION OF THE DESIGNED SOLAR POWERED IRON


Stage 1
Purposive sampling
15 homemakers who used to iron clothes when time permits and frequently gave the clothes for ironing to the ironing man
15 Iron men who commercially clothes and had permanent shops
Stage 2
Standardization of clothes
Homemakers
Ironmen
No. clothes given for ironing per day
No. of members in family.
No. clothes they get for ironing per day
No. of families gives clothes.
Stage 3
Ironing the clothes
Homemakers
Ironmen
Man- 1 cotton shirt and 1 jeans
Women- 1 cotton sari and 1 blouse
Kids- 1 cotton shirt and 1 jeans
Man- 3 cotton shirts and 1 jeans
Women- 2 cotton saris and 1 blouses
Kids- 2 cottons shirt and 1 jeans
Stage 4
Calculating energy consumption



The investigator installed the designed solar powered iron in her residence and checked functioning with the expert's help before evaluating it with the participants. The researcher gave all the necessary instructions to participants on assembling the solar powered iron with a charge controller, battery, and solar panels. Care was taken that the participants did the ironing on a bright sunny day. Hence, only one participant could iron the clothes in one day. It took one month to evaluate the solar powered iron developed by the investigator. After finishing ironing the clothes, the researcher gave a scorecard to participants to mark their opinion on design and operational aspects. For analyzing their responses, the researcher carried out a descriptive method and capered their responses. For calculating the energy consumption, among the 15 homemakers and 15 ironmen, one homemaker and one ironman were selected randomly. Solar powered iron was installed in their house and shops respectively. They were asked to iron the clothes using the solar powered iron for a week. The units consumed for ironing the clothes were noted. Similarly, the investigator asked the participant to iron the clothes using the electric iron for a week and units consumed were note



Organizing an Awareness Program

It includes conducting an awareness program to disseminate knowledge on the significance of using solar home systems, the availability of solar home systems in the market, and energy conservation practices to promote the use of solar home systems to the targeted audience. The main objective of the awareness program was to impart knowledge and improve the attitude and perception of households regarding solar energy home systems.

1. **Conducting awareness program on the functioning of solar home system**

Samples of fifty households were the target audience for the awareness program who showed their willingness to participate in the awareness program during household survey. The

awareness program was conducted in five sessions on the days convenient to the households with 1 hour per day. For imparting knowledge on households, individual contacts, lectures, and group discussions methods were used. Various other communication methods were also utilized to enhance the information conveyed by the researcher and subject expert, such as posters, flyers, leaflets and a booklet. The PowerPoint presentations was also shown to the individuals. E-mail address of the participants were asked to share the presentation to help them for future reference if required. Due to Covid 19 pandemic households were hesitant to participate in community based awareness program hence it was conducted in the residence of the investigator.

Days	**Titles**	**Topic**	**Method**	**Audio-visual aids**
Day 1	Energy scenario of India and energy types Energy conservation and methods	Definition and meaning of energy Type of energy Definition and meaning of energy conservation Various methods of conserving energy	Lecture	Powerpoint presentation
	Need for using alternative sources of energy Introduction to solar energy	Brief explanation on need for using alternative sources of energy Definition and meaning of solar energy Benefits of using solar energy	Lecture	Powerpoint presentation
Day 2	Residential application of solar energy	Solar AC, Solar cooker, Solar lighting , Solar water heater	Lecture Interactive Discussion	Powerpoint presentation, , Slides , Display
Day 3	Residential application of solar energy (cont.)	Solar pumps ,Solar fans , Solar charger, Solar UPS	Lecture Interactive Discussion	Powerpoint presentation, Slides , Display
Day 4	Demonstration of simple solar residential devices	Uses of the devices Operation of the device Care and maintenance of the device	Lecture Expert consultation	Firsthand experience
Day 5	Demonstration of developed solar iron box	Operation of the device Care and maintenance of the device	Lecture Expert consultation	Firsthand experience

Learning module of the awareness program

2. Evaluation of the impact of the solar energy device awareness program

The impact of the awareness program on knowledge, attitude, and perception of solar home systems before and three months after conducting program was tested using an interview schedule.

Phase 1 interview schedule was used to administrate the households before and after three months of the awareness program. The researcher included those sections that dealt with the knowledge, attitude, and perception towards solar home systems in the interview schedule. The investigator used paired t-test and Wilcoxon signed–ranked test to determine the significant difference in knowledge, attitude, and perception.

RESULTS OF THE STUDY

Findings of the Household Survey

The survey among the selected households revealed that majority of the respondents were educated and employed in the age group of 25 yrs.' to 35 yrs.' Above 50 per cent of the respondents belonged to middle income group. Though 52.3 per cent of the respondents were not aware of energy conservation methods all of them had installed one or more devices.

Solar home lighting was used by 62.4 per cent of urban residents and 81.3 per cent of in semi-urban residents. The solar lighting (81.7%) and solar water heaters (31.3%) are more common in independent houses. One hundred percent of households with terraced roofs and 66 per cent of the selected households with tiled roofs used solar home lighting. All households in the plinth area of 300-600 square feet were equipped with five solar lights as part of the Solar Powered Green House Scheme, which provided these households with free electricity. The solar lighting (81.7%) and solar water heaters (31.3%) are more common in independent houses since the government fixed solar lighting in houses provided to the economically weaker section under the CMSPGHS scheme.

According to the data obtained, as household income rose, so did the percentage of households opting to use solar water heaters. Functionality of the device and cost of the device were the factors influencing purchase of the solar device. Cash was the mode of purchase of their solar home systems for a maximum of 57.3 respondents. Though 56.7 per cent never faced any difficulty in the use of solar home systems, total dependence of the devices on solar intensity was expressed as a major difficulty by 57.9 per cent of respondents. Problems due to faulty

installation was the main problem faced after installation of the device. Urban respondents were more knowledgeable on the solar devices than semi-urban respondents.

The results of the study was analysed statistically and the findings are given below:-

Hypothesis (H1) the performance of a solar home system is not impacted by type of neighbourhood on the performance of the solar home system was accepted because the calculated chi-square value for the type of neighborhood was 2.259 which is less than the critical value of 5.991 at a 5 per cent level of significance. Hence, it is inferred that there is no significant association of the neighborhood type on the opinion of the households on the performance of the solar home system.

Hypothesis (H2) there is no significant differences in the mean awareness ratings across the gender and ages of the respondents was accepted because for gender at a 5% level of significance, the calculated t-value was 0.697, which was less than the critical value of 1.966. Men and women had similar levels of awareness score, so we can conclude that there is no significant difference. Sources of information are critical to understand any technology. The same sources of information were used by both men and women, and both groups had a basic understanding of solar energy technology. Because of this, the mean awareness scores of males and females we're not significantly different.

The calculated F-value among different age group was 0.656, which was less than the critical value of 2.395 at a 5 per cent level of significance. Hence, it is inferred that there is no significant difference in the mean awareness scores among different age groups.

Hypothesis (H3) the mean perception score differs significantly among different occupations and income categories of the households was accepted because the F-value for various occupations and income groups was calculated using the ANOVA test. At a 1% level of significance, the F value for different occupations was 5.845, which was higher than the critical value of 3.064. At a 1% level of significance, the F-value for different income categories was 11.521, which was larger than the critical value of 3.367. As a result, it can be deduced that the mean perception score of respondents from various jobs and income levels on the necessity for solar home systems differs significantly.

Findings of awareness program

Hypothesis (H4) the awareness initiative will have a major impact on the average knowledge and perception of the households was accepted because after the awareness program, the researcher found the mean perception score was 44.65, higher than the mean perception score before (19.86). Before and after the awareness program, the mean score on solar home systems' knowledge and benefits was 3.34 and 9.74, respectively. A remarkable increase in participants' knowledge was seen before and after the awareness program from 18 per cent to 90 per cent in the energy conservation practices of the homemakers.

Findings of solar-powered iron and its evaluation

In the case of the design aspects of the solar device, such as weight, length, cord length, appearance, soleplate, and wattage of the device, the level of satisfaction was almost similar among home makers and iron men. Regarding the cost, of the iron box designed only 6.6 per cent of homemakers were satisfied with the cost of the device, whereas more than half of the ironmen (60%) were satisfied. The cost of a solar-powered iron, according to homemakers, was prohibitively expensive. On the other hand, iron men stated that, despite the high initial expense, it is well worth it in the long run.

The operational aspects such as being safe to use on all types of fabrics, removing creases, and being comfortable to use were similar for both the homemakers and iron men. Other operational aspects such as user-friendly, easy operation, rapid heating, simple to store, and effortless to care for and maintain were different.

The homemakers consumed a total of 0.75 units to iron one cotton shirt and jeans of man, one cotton sari and blouse of women, and one cotton shirt and jeans kid’s clothes using solar-powered iron. Whereas ironman consumed 0.15 units to iron 3 cotton shirts and 1 jeans of man, 2 cotton sari and 1 blouse of woman and 2 cotton shirt and 1jeans of kids clothing as iron men are professionals and they took less time to iron the clothes.

CONCLUSION

- The research work has furnished an understanding of the knowledge, attitude, and perception of households on solar energy technology among the households of Coimbatore city.
- Based on the analysis made on the study, the unawareness about solar technology, benefits of using solar home system, knowledge on availability of solar home in the market as well as government initiatives in promoting solar technology among the households remains a concern.
- In the process of elaborate data analysis, it has been understood among various factors to limit the domestic usage of solar home system are its price. The marketers and manufacturers are suggested to bring down the cost of the products so that even the middle income consumers can buy and use these products.
- Households should accept using solar home system in their day-to-day life, as it worthy of the environmental benefits they provide and meet the nation's energy demands.
- Ironed clothes acquired from the solar powered iron designed by the investigator were of good quality and implementation of solar powered iron in daily life will lead in economic savings, facilitate the homemakers to iron their clothes at home instead of giving them out.
- The efficacy of the awareness program has shown an increase in knowledge, attitude, and perception of households of solar energy technology. Moreover, awareness programs have motivated households to adopt other solar devices for daily use.
- Thus, the study has shown a need to educate, motivate, and encourage the households regarding the use of solar home systems, their benefits, and care and maintenance to achieve the current solar energy technology's success and conserve the environment.
- Feedback given by users can be regularly followed by the authorities to ensure consumer satisfaction. As ownership of the house influences the consumer's buying behaviour, builders should be motivated to recommend their clients install solar devices when building a new house.
- The government can help manufacturers and dealers to carry out demonstrations at various locations, which can help people experience the device and get helpful information.

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